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MASTER DEGREE PROGRAM

A/B Testing Mekargo.id Website of Mekar PT Sampoerna Wirausaha with Bayesian Inference and Pymc3

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ABSTRACT

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Chapter 1

INTRODUCTION

1.1 Background

Usaha Kecil Menengah (UKM) memiliki peran penting dalam mendorong pertumbuhan perekonomian Indonesia. Dengan adanya sektor UKM, pengangguran akibat angkatan kerja yang tidak terserap dalam dunia kerja menjadi berkurang. Sektor UKM pun telah terbukti menjadi pilar perekonomian yang tangguh. Kontribusi sektor UKM dalam menentukan Produk Domestik Bruto (PDB) dan sektor penghasil devisa negara juga tak perlu diragukan lagi. Saat ini, UKM telah dijadikan agenda utama pembangunan ekonomi Indonesia (Kemenkeu, 2015).

Masalah mendasar UKM yang paling menonjol menyangkut menyediakan pembiayaan usaha alias modal usaha. Kebutuhan modal sangat terasa pada saat seseorang ingin memulai usaha baru. Alhasil, biasanya bila motivasinya kuat, seseorang akan tetap memulai usaha dengan modal seadanya. Pada usaha yang sudah berjalan, modal tetap menjadi kendala lanjutan untuk berkembang. Masalah yang menghadang UKM menyangkut kemampuan akses pembiayaan, akses pasar dan pemasaran, tata kelola manajemen usaha kecil serta akses informasi. Kesulitan UKM mengakses sumber-sumber modal karena keterbatasan informasi dan kemampuan menembus sumber modal tersebut. Padahal pilihan sumber modal sangat banyak dan beragam. Lembaga keuangan bank adalah sumber modal terbesar yang dapat dimanfaatkan oleh pelaku usaha kecil. Namun untuk bermitra dengan bank, usaha kecil dituntut menyajikan proposal usaha yang feasible atau layak usaha dan menguntungkan (Wuisan, 2017).

Mekar (PT Sampoerna Wirausaha) didirikan pada 2010 dan dimiliki secara penuh oleh Putera Sampoerna Foundation, Mekar bertujuan untuk mempermudah akses finansial bagi para pelaku UKM Indonesia sehingga memiliki dampak sosial dan ekonomi yang positif di Indonesia (Mekar, 2017). Mekar memberikan solusi dalam membantu Pelaku Usaha Mikro Kecil dan Menengah (UMKM) dan Konsumen lainnya untuk mendapatkan Akses Layanan Keuangan atau Permodalan di Indonesia. Beberapa produk yang dimiliki Mekar diantaranya website utama Mekar.id, chat bot dan website Mekar Go. Website Mekar Go dengan alamat web https://mekargo.id/ merupakan website untuk menghimpun data UKM dan karyawan yang ingin mengajukan pinjaman ke MEKAR. Data yang telah dihimpun pada versi web saat ini menunjukkan konversi peminjam yang melengkapi pengisian data dari awal sampai akhir kurang dari 10%. Presentase konversi ini menurut tim marketing terlalu kecil dan perlu ditingkatkan.

Untuk meningkatkan presentase konversi pelengkapan data, tim marketing mengusulkan perubahan urutan pengisian data. Perubahan urutan pengisian data dibuat menjadi dua versi baru yang selanjutnya disebut sebagai versi B dan versi C, dan versi saat ini disebut sebagai versi A. Ketiga versi tersebut akan dilakukan A/B testing untuk mengetahui versi manakah yang menghasilkan presentasi konversi pelengkapan data terbanyak. A/B testing adalah proses yang digunakan dalam marketing untuk mengisolasi dan menguji faktor-faktor yang mempengaruhi performa versi produk mana yang memenuhi kriteria marketing (Dixon et al., 2015). A/B testing banyak digunakan untuk pengoptimalan situs web: dua versi halaman web, katakanlah A dan B, secara empiris dibandingkan dengan disajikan kepada pengguna. Setiap pengguna hanya melihat salah satu dari dua versi, dan tujuannya adalah untuk menentukan versi mana yang lebih baik. Tujuan yang ingin dicapai pada umumnya adalah untuk menentukan halaman web mana yang memiliki tingkat konversi tertinggi (kemungkinan pengguna benar-benar menjadi pelanggan) dengan menerima umpan balik dari pengguna (Kaufmann et al., 2014). Dalam penelitian ini, pengumpulan data umpan balik dari pengguna dibantu dengan tools Google Analytics. Google Analytics merupakan analytics tool yang dibuat oleh Google, digunakan untuk mengukur performa website dan perilaku pengguna saat mengunjungi website (Yang and Perrin, 2014). Setelah data yang dikumpulkan oleh Google Analytics terpenuhi, dilakukan proses analisis data dengan metode bayessian infer-

ence dan tools pymc3. Pymc3 adalah framework probabilistik programming dengan bayessian inference yang ditulis dalam bahasa pemrograman python (Salvatier et al., 2016).

1.2 Formulation of the Problem

Adapun masalah yang dibahas pada penelitian ini adalah bagaimana metode yang dilakukan untuk melakukan A/B testing website mekargo.id pada PT Mekar Sampoerna Wirausaha, bagaimana cara menganalis hasil A/B testing dengan metode bayesian inference dengan tools pymc3, dan varian manakah dari A/B testing yang menjadi varian terbaik.

1.3 Scope of Problem

Adapun batasan masalah dari penelitian ini adalah sebagai berikut:

1. Objek penelitian adalah website mekargo.id.
2. Penelitian dilakukan di PT Mekar Sampoerna Wirausaha.
3. Waktu penelitian antara Agustus 2017 sampai Januari 2018.
4. Penelitian menerapkan taknik A/B testing pada website mekargo.id dengan bantuan tools Google Analytics.
5. Data yang dihasilkan dari A/B testing dilakukan analisis dengan metode bayesian inference menggunakan tools library pymc3, numpy, matplotlib, scipy, jupyter dan Ipython dengan bahasa pemrograman python.
6. Fitur website mekargo.id yang dibahas adalah fitur pengisian data peminjam.
7. Fitur website mekargo.id yang tidak dibahas adalah fitur static page yang berisi halaman home, about us, terms and conditions, privacy policy dan contact us.

1.4 Research Purposes

Tujuan dari penelitian ini adalah melakukan A/B testing website mekargo.id pada PT Mekar Sampoerna Wirausaha, melakukan analisis hasil A/B testing dengan metode bayesian inference dengan pymc3, mengetahui variant pada A/B testing yang menjadi varian terbaik.

1.5 Research Benefits

Manfaat yang didapat dari penelitian ini adalah:

1. Bagi peneliti, menjadi panduan atau referensi penelitian di bidang sistem informasi pada penelitian selanjutnya.
2. Bagi peneliti lain, sebagai sumber literatur untuk penelitian yang sejenis.
3. Bagi perusahaan yang diteliti, memberikan saran perbaikan dengan terpilihnya varian A/B testing yang terbaik.

Chapter 2

LITERATURE REVIEW

2.1 Python

Python is a dynamically typed programming language that has a focus on ease of use and readability. Due in part to this focus, it has become a popular language for scientific computing and data science, with a broad ecosystem of libraries (Meurer et al., 2017). Python syntax is designed very readable, which is important for software development. Every computer program is written only once, but read and revised many times, often by many people. Being readable also makes it easier to learn and remember, hence more writeable. Compared with other popular languages, Python has a gentle learning curve that makes developer more productive, yet it has depths that can be explored and gain expertise (Lubanovic, 2014).

People use python because have these several advantages: software quality, developer productivity, program portability, support libraries, component integration, and enjoyment (Lutz, 2013). For application development, Python has advadtages of ease for development and prototyping (Vohl et al., 2016). Python is a multi-platform, general-purpose programming language that can run on Windows, Linux/Unix, and Mac OS X, and has been ported to Java and .NET virtual machines as well. It has a powerful standard library. In addition, it has many libraries for data analysis such as Numpy, Pandas, Matplotlib, PyMongo, and Scikit (Vo et al., 2015). Python is the most popular programming languages in the scientific domains (Rougier et al., 2017). The frequency of programming languages appearing in Journal of Open Source Software (JOSS) articles show that Python appears the most with over half

of published articles in total 54 (Smith et al., 2018).

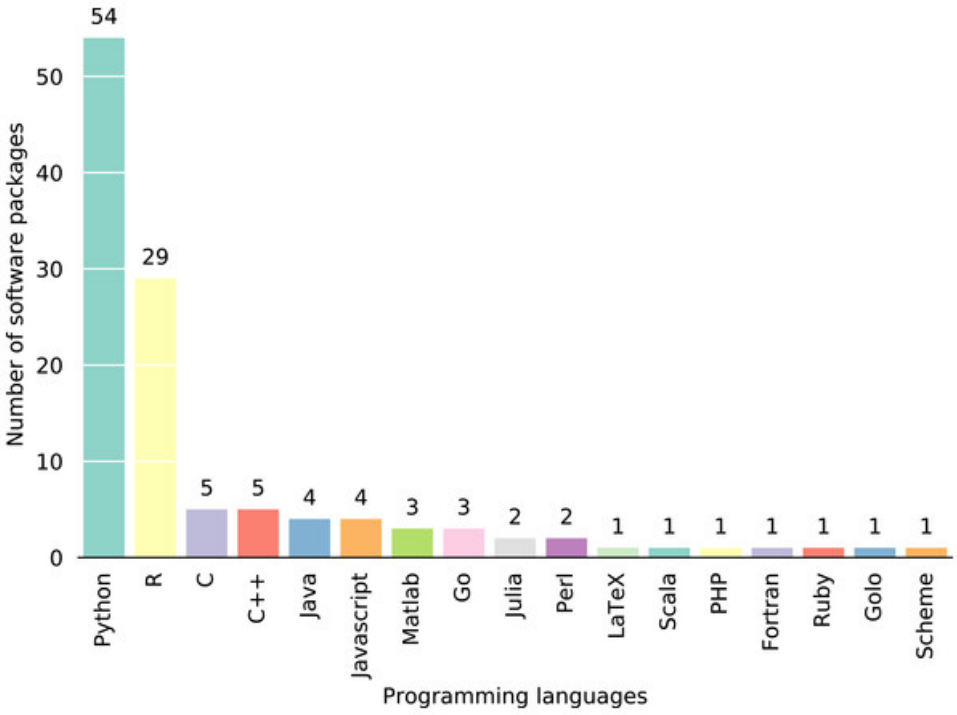


Figure 2.1: Python programming language usage in JOSS articles
Source: Smith et al., 2018

2.2 Numpy

Numpy is a fundamental package that is extremely useful for scientific computing, and contains among other things a powerful N-dimensional array object (Strickland et al., 2014). The Numpy package, which comprises the Numpy array as well as a set of accompanying mathematical functions, has found wide-spread adoption in academia, national laboratories, and industry, with applications ranging from gaming to space exploration (Van Der Walt et al., 2016).

2.3 Matplotlib

Matplotlib is a python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms. Matplotlib can be used in python scripts, the python and

ipython shell, web application servers, and six graphical user interface toolkits (Hunter et al., 2014). Matplotlib provides both a very quick way to visualize data from Python and publication-quality figures in many formats: line plots, contour plots, scatter plots, and basemap plots. It comes with a set of default settings, but allows customization of all kinds of properties. However, we can easily create our chart with the defaults of almost every property in Matplotlib (Vo et al., 2015).

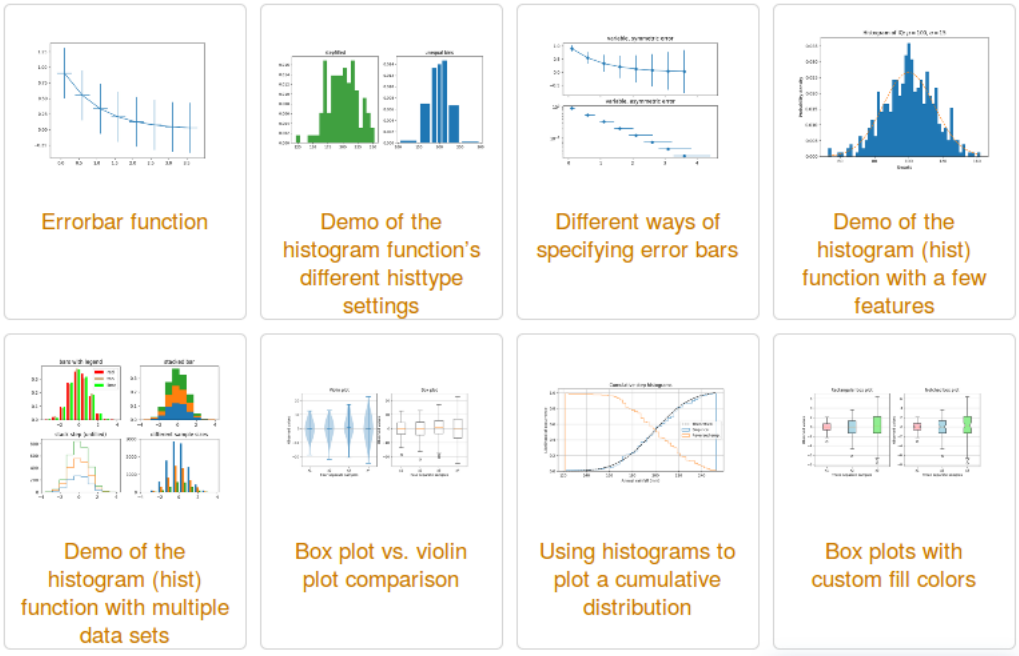


Figure 2.2: Some examples of matplotlib chart
Source: Hunter et al., 2014

2.4 Scipy

Scipy (pronounced “Sigh Pie”) is a Python-based ecosystem of open-source software for mathematics, science, and engineering. Scipy ecosystem includes general and specialised tools for data management and computation, productive experimentation and high-performance computing. The SciPy library, a collection of numerical algorithms and domain-specific toolboxes, including signal processing, optimization, statistics and much more (Jones et al., 2014).

2.5 Ipython

Ipython is an interactive browser-based environment where you can combine code execution, text, mathematics, plots, and rich media into a single document. Originally designed for use as an electronic lab notebook for computational science, it is increasingly being used in teaching as well, and a rich ecosystem of open source plugins and extensions for teaching is growing around it (Wilson et al., 2014). IPython has provided terminal-based tools for interactive computing in Python since 2001. The notebook document format and multi-process architecture introduced in 2011 have expanded the applicable scope of IPython into teaching, presenting, and sharing computational work, in addition to interactive exploration (Ragan-Kelley et al., 2014).

2.6 Jupyter

Jupyter Notebook, provides a tool to create and share web pages with text, charts, and Python code in a special format. Often, the notebooks are used as an educational tool, or to demonstrate Python software. We can import or export notebooks either from plain Python code or from the special notebook format. The notebooks can be run locally, or we can make them available online by running a dedicated notebook server (Fandango and Idris, 2017).

Jupyter Notebook is accessed through a modern web browser. This makes it practical to use the same interface running locally like a desktop application, or running on a remote server. In the latter case, the only software the user needs locally is a web browser; so, for instance, a teacher can set up the software on a server and easily give students access. The notebook files it creates are a simple, documented JSON format, with the extension '.ipynb'. It is simple to write other software tools which access and manipulate these files (Kluyver et al., 2016).

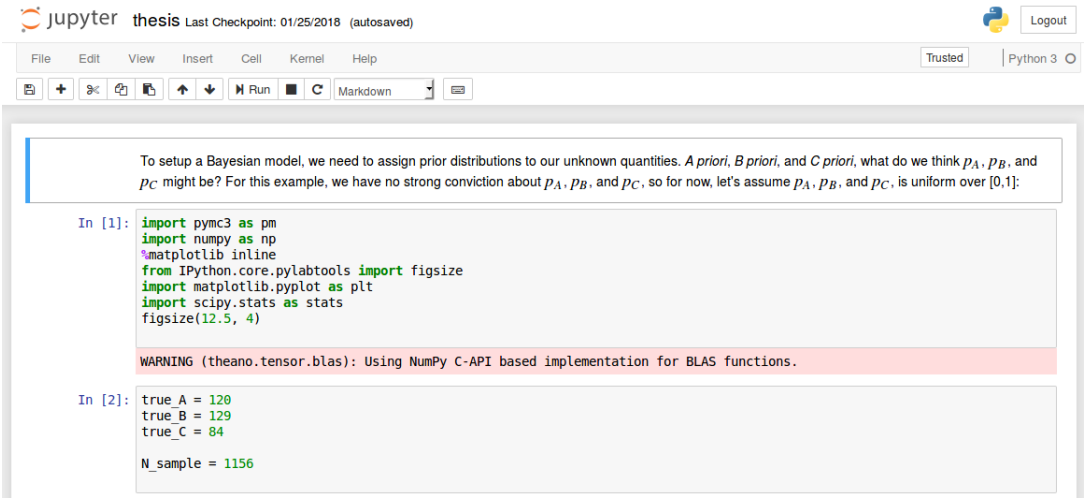


Figure 2.3: Jupyter notebook interface

2.7 Bayesian Inference

Bayesian inference is the process of fitting a probability model to a set of data and summarizing the result by a probability distribution on the parameters of the model and on unobserved quantities such as predictions for new observations (Gelman et al., 2014). Bayesian inference differs from more traditional statistical inference by preserving uncertainty. The Bayesian worldview interprets probability as measure of believability in an event, that is, how confident we are in an event occurring. In fact, we will see in a moment that this is the natural interpretation of probability (Davidson-Pilon, 2015).

Bayesian inference departs from the approach to statistical inference described in many textbooks, which is based on a retrospective evaluation of the procedure used to estimate θ (or $\tilde{y}$) over the distribution of possible y values conditional on the true unknown value of θ. Despite this difference, it will be seen that in many simple analyses, superficially similar conclusions result from the two approaches to statistical inference. However, analyses obtained using Bayesian methods can be easily extended to more complex problems (Gelman et al., 2014).

The Bayesian modeling paradigm involves setting up a probabilistic model describing how data was gen- erated, assigning prior distributions over unknown model parameters, and then calculating a posterior distribution over these parameters. In practice, this posterior distribution is often intractable to compute exactly except for the simplest models. This often requires one

to resort to approximate posterior inference algorithms based on Monte-Carlo sampling or Variational Inference (VI). Fortunately, a lot of progress has been made recently in this area including state-of-the-art algorithms such as Hamiltonian Monte Carlo sampling (HMC), the No-U-Turn Sampler (NUTS), Automatic Differentiation VI (ADVI) and Black Box VI. These algorithms are applica- ble to a wide class of models and are readily available in popular Probabilistic Programming languages such as Stan, Edward, and PyMC3 (Pourzanjani et al., 2017). Bayesian inference had been applied in many areas such as automatic machine-learning hyperparameter optimization, A/B testing or recommender systems, among others (Jiménez and Ginebra, 2017).

Some advantages of the Bayesian approach are: that it provides a transparent framework for inference; secondly, it is flexible and often provides an elegant and practical solution to inference arising from very complex statistical models. Note, in particular, that Bayesian methods make no formal distinction between estimation oand prediction, and in this way naturally incorporate parameter uncertainty into predictive inference. Because, obtaining the sample can itself be a major challenge (Taylor et al., 2015).

2.8 Markov Chain Monte Carlo

Markov Chain Monte Carlo (MCMC) method is used to generate samples from a probability distribution. It is widely used nowadays in many aspects of optimization and numerical integration, and is specially suitable for being used in sampling from posterior distributions in Bayesian inference. A key issue in MCMC is whether the chain has converged and is actually sampling from the target distribution. There is not a single infallible test of convergence, but many formal and informal ways to assess non-convergence (Fernández-i Marín et al., 2016).

Markov chain Monte Carlo is a general method based on drawing values of θ from approximate distributions and then correcting those draws to better approximate the target posterior distribution, $p(\theta|y)$. The sampling is done sequentially, with the distribution of the sampled draws depending on the last value drawn; hence, the draws form a Markov chain. (As defined in probability theory, a Markov chain is a sequence of random variables θ^1 , θ^2 , . . ., for which, for any t, the distribution of θ^t given all previous θ's

depends only on the most recent value, θ^{t-1} .) The key to the method's success, however, is not the Markov property but rather that the approximate distributions are improved at each step in the simulation, in the sense of converging to the target distribution (Gelman et al., 2014).

2.9 Pymc3

PyMC3 is a new, open-source probabilistic programming framework with an intuitive and readable, yet powerful, syntax that is close to the natural syntax statisticians use to describe models. It features next-generation Markov chain Monte Carlo (MCMC) sampling algorithms (Salvatier et al., 2016). Running PyMC3 requires a working Python interpreter (Python Software Foundation, 2010), either version 2.7 (or more recent) or 3.4 (or more recent). PyMC3 can be installed using 'pip': pip install pymc3. PyMC3 depends on several third-party Python packages which will be automatically installed when installing via pip (Salvatier et al., 2016).

The majority of the heavy lifting done by PyMC3 is taken care of with the theano package. The notation in theano is remarkably similar to NumPy. It also supports many of the familiar computational elements of NumPy. However, while NumPy directly executes computations, e.g. when you run a + b, theano instead builds up a "compute graph" that tracks that you want to perform the + operation on the elements a and b. Only when you eval() a theano expression does the computation take place (i.e. theano is lazy evaluated). Once the compute graph is built, we can perform all kinds of mathematical optimizations (e.g. simplifications), compute gradients via autodiff, compile the entire graph to C to run at machine speed, and also compile it to run on the GPU. PyMC3 is basically a collection of theano symbolic expressions for various probability distributions that are combined to one big compute graph making up the whole model log probability, and a collection of inference algorithms that use that graph to compute probabilities and gradients (Davidson-Pilon, 2015).

2.10 Theano

Theano is a Python library that allows to define, optimize, and evaluate mathematical expressions involving multi-dimensional arrays efficiently. Since its introduction in it has been one of the most used CPU and GPU mathematical compilers – especially in the machine learning community and has shown steady performance improvements. Theano is being actively and continuously developed since 2008, multiple frameworks have been built on top of it and it has been used to produce many state-of-the-art machine learning models. Theano allows a user to symbolically define mathematical expressions and have them compiled in a highly optimized fashion either on CPUs or GPUs (the latter using CUDA) 1 , just by modifying a configuration flag. Furthermore, Theano can automatically compute symbolic differentiation of complex expressions, ignore the variables that are not required to compute the final output, reuse partial results to avoid redundant computations, apply mathematical simplifications, compute operations in place when possible to minimize the memory usage, and apply numerical stability optimization to overcome or minimize the error due to hardware approximations. To achieve this, the mathematical expressions defined by the user are stored as a graph of variables and operations, that is pruned and optimized at compilation time.

The interface to Theano is Python, a powerful and flexible language that allows for rapid prototyping and provides a fast and easy way to interact with the data. The downside of Python is its interpreter, that is in many cases a poor engine for executing mathematical calculations both in terms of memory usage and speed. Theano overcomes this limitation, by exploiting the compactness and ductility of the Python language and combining them with a fast and optimized computation engine. Theano's API mimics NumPy, a widely adopted Python library that provides an n-dimensional array data type and many functions for indexing, reshaping, and performing elementary computations (exp, log, sin, etc.) on entire arrays at once. This allows Python users to rapidly switch to Theano using a familiar syntax and set of instructions – extended with advanced features, such as automatic gradient computation, numerical stability improvements and optimization – and generate a high-performance code for CPU as well as for GPU, without requiring changes to the user code. Theano has also been designed for easy and fast

extensibility through the definition of custom graph expressions written in Python, C++, or CUDA (Al-Rfou et al., 2016).

2.11 Google Analytics

Google Analytics (GA) is an easy-to-use tool to measure activity on a website. A basic setup might take as little as a few minutes, and many of the standard reports are quite accessible and understandable without any special training or prior knowledge of web analytics. Because of this, many users jump into GA without knowing much about its underpinnings—how the data is structured and gathered—and that's fine for the basics. But eventually, users can outgrow this intuitive understanding of GA and its data, and need deeper insight into how it works and what it can do (Weber, 2015).

Google Analytics is free, and it is always increasing in power, to rival and in some cases exceed the performance of the "paid" tools (Kelsey, 2017). Google Analytics has another advantages such as has tremendous features, and ease of use. Unlike other Web analytics tools that use server log files, Google collects information by inserting simple Javascript codes into Web pages. The advantage of this method is that Google Analytics can capture technical and demographic information that log files do not normally provide, such as the user's browser, operating system, screen size, resolution, and so on (Yang and Perrin, 2014).

2.12 A/B Testing

A/B testing has widely become the standard controlled experimentation framework for network driven companies like Facebook, LinkedIn, Twitter, Google, and Yahoo (Wilson and Uminsky, 2017). A/B testing is ubiquitous within the machine learning and data science operations of internet companies. Generically, the idea is to perform a statistical test of the hypothesis that a new feature is better than the existing platform. For example, it results in higher revenue (Goldberg and Johndrow, 2017).

A/B testing started to be used in the late 1990s with the growth of the Internet. Many large companies run thousands to tens of thousands of A/B testing each year testing user interface (UI) changes, enhancements to al-

gorithms (search, ads, personalization, recommendation, etc.), changes to apps, content management system, etc. In an A/B testing, users are randomly split between the variants (e.g., the two different ads layouts) in a persistent manner (a user receives the same experience in multiple visits). Their interactions with the site are instrumented and key metrics computed (Kohavi and Longbotham, 2017).

In A/B testing, one has a proposed new version of a software platform and wants to decide whether or not to ship the new version. The classical way of conceiving of this problem is the following. We divide users into two groups: treatment and control. We then roll out the proposed update to the treatment group while leaving the control group with the current version. Using data gathered from this randomized trial, we then ask whether the new version performed "better" with respect to some metric (Goldberg and Johndrow, 2017).

2.13 Previous Researches

Table 2.1 contains previous researches on A/B testing.

Table 2.1: Previous research

No	Article	Authors	Strength	Weakness
1	A Decision Theoretic Approach to A/B Testing(Goldberg and Johndrow, 2017)	David Goldberg (eBay) and James E. Johndrow (Stanford University)	Great on Mathematical concept explanation	Lack of application example

No	Article	Authors	Strength	Weakness
2	Always Valid Inference: Bringing Sequential Analysis to A/B Testing(Johari et al., 2015)	Ramesh Johari, Leo Pekelis and David J. Walsh	Great on real world example and Mathematical concept explanation. Also contains Supplementary Material	There is no proof of theorem explanation
3	Online Controlled Experiments and A/B Testing(Kohavi and Longbotham, 2017)	Ron Kohavi (Microsoft) and Roger Longbotham (Microsoft)	Great on real world example	Lack of Mathematical concept explanation
4	Online Controlled Experiments at Large Scale (Kohavi et al., 2013)	Ron Kohavi (Microsoft), Alex Deng (Microsoft), Brian Frasca (Microsoft), Toby Walker (Microsoft), Ya Xu (Microsoft), and Nils Pohlmann (Microsoft)	Great on real world example	Lack of Mathematical concept explanation

No	Article	Authors	Strength	Weakness
5	On the Complexity of A/B Testing (Kaufmann et al., 2014)	Emilie Kaufmann (LTCI, Télécom ParisTech & CNRS) , Olivier Cappé (LTCI, Télécom ParisTech & CNRS), and Aurélien Garivier (Institut de Mathéma-tiques de Toulouse, Université Paul Sabatier)	Great on Mathemati-cal concept explanation	Lack of application example

No	Article	Authors	Strength	Weakness
6	The Power of A/B Testing under Interference (Wilson and Uminsky, 2017)	James D. Wilson (Department of Mathematics and Statistics University of San Francisco) and David T. Uminsky (Department of Mathematics and Statistics University of San Francisco)	Great on real world example and Mathematical concept explanation. Also, completed with proof of theorem explanation	There is no Supplementary Material

Chapter 3

RESEARCH METHODOLOGY

3.1 Research Object

Waktu penelitian dilakukan antara bulan Agustus 2017 sampai Januari 2018. Objek pada peneltian ini adalah website mekargo.id PT Mekar Investama Sampoerna. (jabarin mekargo dan mekar investama). Fitur yang diteliti adalah fitur pendaftaran bagi peminjam. Data yang digunakan adalah alamat url yang dikunjungi pendaftar untuk masing-masing versi A/B testing. Pengumpulan data dilakukan dengan tools google analytics. Data yang didapatkan selanjutnya akan dianalisis dengan metode bayesian inference dan tools pymc3.

3.2 Research Methodology

Metode penelitian yang dilakukan meliputi: identifying problems, defining website measurement, developing a hypothesis, developing and testing page variants, dan analyzing test results. Gambaran langkah metode penelitian yang dilakukan dapat diilustrasikan oleh figure 3.1.

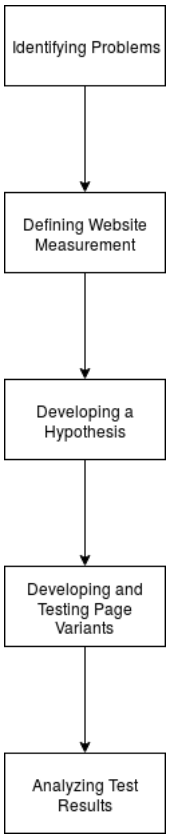


Figure 3.1: Research Methodology

3.2.1 Identifying Problems

Masalah yang diidentifikasi adalah yang berhubungan dengan website yang akan dilakukan A/B testing. Masalah yang diangkat biasanya berhubungan dengan bisnis, marketing, atau convertion rate. Tergantung pada tujuan apa yang ingin dicapai pada pembuatan A/B testing pada website tersebut.

3.2.2 Defining Website Measurement

Website measurement terdiri dari penjelasan poin indikator bisnis yang terdiri dari business objective, website goal, key performance metric, dan target metric.

Business objective adalah bla bal bla. Website goal adalah bla bla. Key performance metric adalah bla bla. Target metric adalah bla bla bla.

3.2.3 Developing a Hypothesis

lihat kata2 dari website

Asumsi awal yang menjadi penyebab masalah pada point 3.3.1 disertai dengan pengajuan solusi yang akan diterapkan. Menyebutkan hasil akhir dari solusi yang diajukan disertai alasannya.

3.2.4 Developing and Testing Page Variants

develop, menjelasin tool analytic, penjelasan proses percobaan.

3.2.5 Analyzing Test Results

menjelasin konsep, metode, algoritma, dan tools program di pymc jupyter

3.2.5.1 Bayessian Inference Algorithm

Let $X_1, ..., X_n$ be n observations sampled from a probability density $p(x|\theta)$. Write $p(x|\theta)$ if θ as a random variable and $p(x|\theta)$ represents the conditional probability density of X conditioned on θ. In contrast, write $p_\theta(x)$ if θ as a deterministic value.

3.2.5.2 Bernoulli Distribution

Bernoulli distribution pada penelitian digunakan untuk ..., dibuat dengan library scipy dengan pada modul scipy.stats.bernoulli

The Bernoulli distribution is a discrete distribution having two possible outcomes labelled by $n = 0$ and $n = 1$ in which $n = 1$ ("success") occurs with probability p and $n = 0$ ("failure") occurs with probability $q = 1 - p$, where $0 < p < 1$. It therefore has probability density function

$$p(n) = p^n(1 - p)^{1-n}.$$

The distribution of heads and tails in coin tossing is an example of a Bernoulli distribution with $p = q = 1/2$. The Bernoulli distribution is the simplest discrete distribution, and it the building block for other more complicated discrete distributions (Weisstein, 2018).

Algoritma 3.1 Bayesian inference algorithm

1. Choose a probability density $\pi(\theta)$ — called the prior distribution — that expresses beliefs about a parameter θ.
2. Choose a statistical model $p(x|\theta)$ that reflects beliefs about x given θ.
3. After observing data $D_n = \{X_1, ..., X_n\}$, update beliefs and calculate the posterior distribution $p(\theta|D_n)$. The posterior distribution can be written as:

$$p(\theta|X_1, ..., X_n) = \frac{p(X_1, ..., X_n|\theta)\pi(\theta)}{p\left(X_1, ..., X_n\right)} = \frac{\mathcal{L}_n\left(\theta\right)\pi\left(\theta\right)}{c_n}\alpha\mathcal{L}_n\left(\theta\right)\pi\left(\theta\right)$$

where $\mathcal{L}_n\left(\theta\right) = \prod_{i=1}^{n} p\left(X_i|\theta\right)$ is the likelihood function and

$$c_n = p\left(X_1, ..., X_n\right) = \int p(X_1, ..., X_n|\theta)\pi(\theta)d\theta = \int \mathcal{L}_n\left(\theta\right)\pi\left(\theta\right)d\theta$$

is the normalizing constant, which is also called the evidedence (Liu and Wasserman, 2014).

3.2.5.3 Pymc3

Pymc3 in analyzing test results of this research is used as probabilistic programming tools for bayesian inference method to build probabilistic models. Probabilistic programming offers an effective way to build complex models and allows us to focus more on model design, evaluation, and interpretation, and less on mathematical or computational details (Martin, 2016).

3.2.5.4 Metropolis-Hastings Algorithm

Metropolis-Hastings algorithm (MH) is one of special forms of the Hastings algorithm. The Hastings algorithm (HA) is a stochastic sampling technique widely used throughout computational science. As a Markov Chain Monte Carlo method, HA does not attempt to generate a sequence of independent samples from a "target distribution" $\pi(\cdot)$, defined on the state space(E, ε), but rather a Markov chain $\{Xn, n = 1, 2, 3, ...\}$ having $\pi(\cdot)$ as its invariant distribution. Although variates in the chain are not independent, they may nonetheless be used to estimate statistical expectations with respect to $\pi(\cdot)$.

Let $U(0, 1)$ represent the uniform distribution on (0, 1). In order to use all subsequently described algorithms, given $X_n = x$, we require a "proposal density" $\gamma(\cdot|x)$ which may (or may not) depend on x, and whose variates can be generated by other means. Given $X_n = x \sim \pi(\cdot)$, we can generate $X_{n+1} \sim \pi(\cdot)$ by

Algoritma 3.2 Metropolis-Hastings Algorithm

1. Generate $y \sim \gamma(\cdot|x)$ and $r \sim U(0, 1)$
2. If $r \leq \alpha_{HA}(x, y)$, output $X_{n+1} = y$
3. Else, output $X_{n+1} = x$ where densities are assumed to be symmetric (that is, $\gamma(x|y) = \gamma(y|x)$) and the acceptance probability in Step 3 is $\alpha_{HA}(x, y) = min\left\{\frac{p(y)}{p(x)}, 1\right\}$ (Minh and Minh, 2015).

Chapter 4

RESULTS AND DISCUSSION

Adapun hasil dan pembahasan dari penelitian ini adalah sebagai berikut:

4.1 Identify Problems

jelaskan versi sebelum ab testing seperti apa, kondisinya bagaimana, yang dihasilkan, dan masalahnya apa, yang timbul dan penyebab kira kira

presentase pendaftar yang menyelesaikan pengisian data masih belum mencapai presentase minimal yang ditetapkan.

4.2 Define Website Measurement

4.2.1 Business Objective

Menambah jumlah peminjam yang akan diberikan pinjaman peer-to-peer lending.

To test which site is the highest successfully completed Loan Access and Survey submitted?

4.2.2 Website Goal

Meningkatkan jumlah peminjam yang mendaftar, meningkatkan presentase penyelesaian pengisian form pendaftaran oleh peminjam. Macro Goal: visitors completed submitting on loan access; Micro Goal: visitors completed submitting survey;

4.2.3 Key Performance Metric

jumlah pendaftar per bulan, presentase penyelesaian pengisian form oleh peminjam saat pengisian form pendaftaran.

Traffic Level, High and Low Traffic during the test period.

conversion level

4.2.4 Target Metric

500 pendaftar selama sebulan, presentase penyelesaian data di atas 10%.

4.3 Develop a Hypothesis

Presentase penyelesaian pengisian form pendaftaran dipengaruhi oleh urutan pengisian form. Apabila diubah akan meningkatkan presentasenya. Solusi yang diajukan adalah melakukan pengujian A/B testing terhadap dua versi baru disertai dengan penyederhanaan dan penyingkatan pengisian data. Asumsi awal, salah satu dari dua versi baru ini akan lebih baik daripada versi yang sebelumnya.

4.4 Developing and Testing Page Variants

4.4.1 Developing Page Variants

menjelaskan 3 versi, satu control 2 varian, dilihatin bentuk formnya.

perubahan yang dilakukan: Remove unnecessary data fields and some data fields are changed to optional

Table 4.1: Data fields changes

Part	Fields Name	Remove	Optional	New
Personal Detail Information	Alamat Usaha / Tempat Bekerja (Provinsi, Kota, Kecamatan, Kelurahan)	v		
	Bidang Jenis Usaha / Jenis Pekerjaan	v		

Part	Fields Name	Remove	Optional	New
	Lama Usaha / Lama Bekerja	v		
	Jumlah Karyawan	v		
	Foto Tempat Usaha	v		
	Status Karyawan	v		
	Email		v	
	Foto KTP		v	
	Tanggal Lahir			v
Jaminan	Foto Tanah + Bangunan		v	
	Foto Kendaraan Bermotor		v	

Untuk membedakan versi A/B testing, digunakan suffik satu huruf alfabet (a atau b atau c) sesuai dengan jenis varian.

Table 4.2: Url definition

Step	Site A (/ukm/a/)	Site B (/ukm/b/)	Site C (/ukm/c/)
Survey Page	/ukm/a/survei	/ukm/b/survei	/ukm/c/survei
Detail Needs Page	/ukm/a/detil-survei	/ukm/b/detil-survei	/ukm/c/detil-survei
Personal Information Page	/ukm/a/data-diri	/ukm/b/data-diri	/ukm/c/data-diri
Thanks Page	/ukm/a/terima-kasih	/ukm/b/terima-kasih	/ukm/c/terima-kasih
Detail Loan Access Page	/ukm/a/ pinjaman	/ukm/b/ pinjaman	/ukm/c/ pinjaman
Ekstra Pesonal Detail Information Page	/ukm/a/ tambahan-data-diri	-	-
Congrats Page	/ukm/a/selamat	/ukm/b/selamat	/ukm/c/selamat

jelaskan dan sebutkan setiap alur url A/B/c (bisa dalam bentuk chart urutan step)

a Survey Page,

b Survey Page, Personal Information Page

c Survey Page,

kasih reference ke lampiran gambar

pembagian traffic round robbin

Listing 4.1: Round robin class

```
class RoundRobin(models.Model):
    flow_type = models.CharField(max_length=1, null=True)
    partner_slug = models.SlugField(null=True)
    def next(self):
        latest = self.flow_type
        if latest == 'a':
            return 'b'
        elif latest == 'b':
            return 'c'
        elif latest == 'c':
            return 'a'

if RoundRobin.objects.count() == 0:
    next_flow = 'a'
else:
    latest = RoundRobin.objects.last()
    next_flow = latest.next()
```

4.4.2 Testing Page Variants

pengujian A/B testing dilakukan dari tanggal 24 September 2017 sampai 23 Oktober 2017. Traffic tinggi terjadi pada tanggal ..., ..., dan ... Yang tertinggi pada tanggal ... dan yang terendah pada tanggal ...

cleaning data membuang dari bot

Listing 4.2: Google Analytics implementation

```
<!-- Global Site Tag (gtag.js) - Google Analytics -->
<script async src="https://www.googletagmanager.com/gtag/
    js?id=UA-70057602-1">
```

```
</script>
<script>
  window.dataLayer = window.dataLayer || [];
  function gtag(){dataLayer.push(arguments);}
  gtag('js', new Date());
  gtag('config', 'UA-70057602-1');
</script>
```

penerapan data collection dengan google analytic.

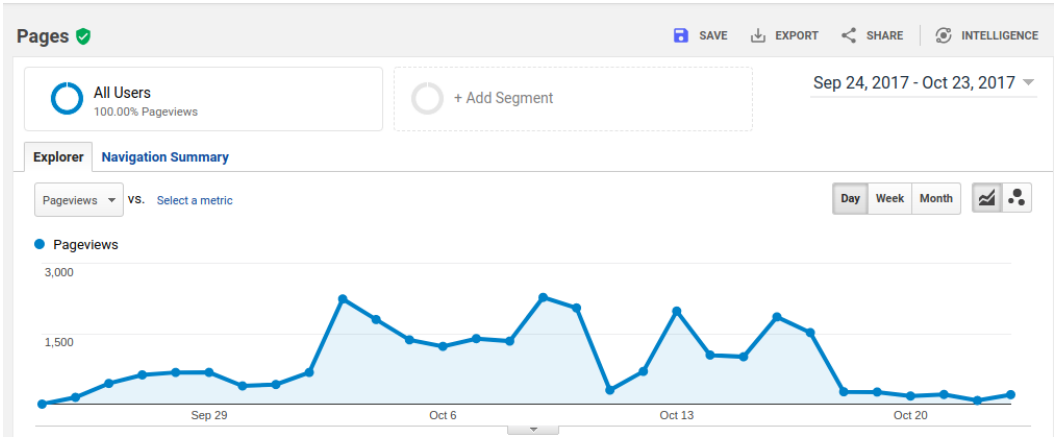
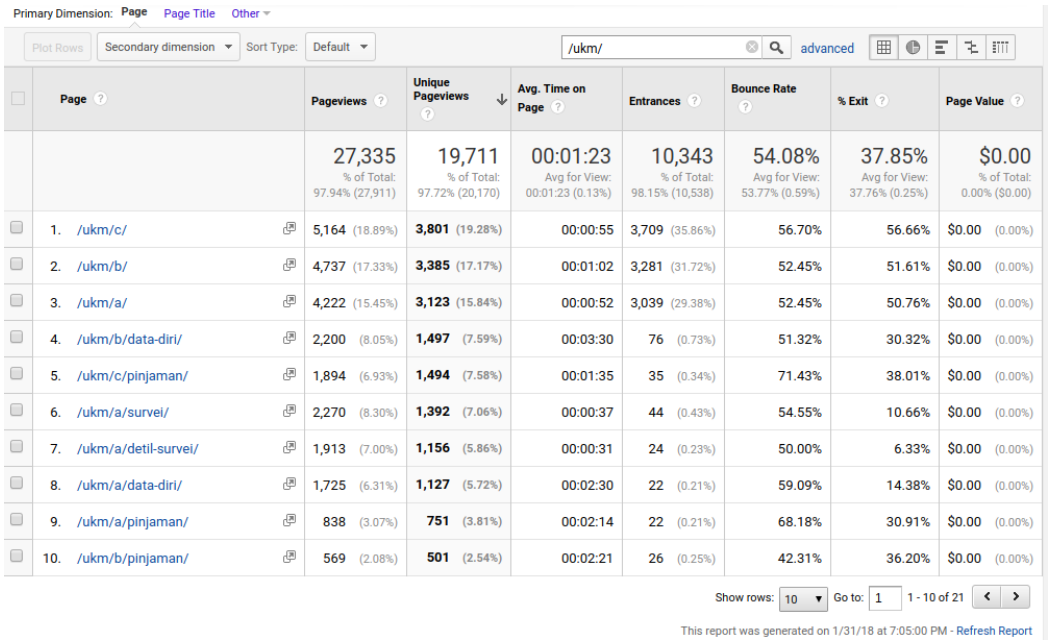


Figure 4.1: Graphic google analytics mekargo.id

menjelaskan gambar.



Primary Dimension: Page | Page Title | Other

Plot Rows | Secondary dimension | Sort Type: Default | /ukm/ | advanced

	Page	Pageviews	Unique Pageviews	Avg. Time on Page	Entrances	Bounce Rate	% Exit	Page Value
		27,335 % of Total: 97.94% (27,911)	19,711 % of Total: 97.72% (20,170)	00:01:23 Avg for View: 00:01:23 (0.13%)	10,343 % of Total: 98.15% (10,538)	54.08% Avg for View: 53.77% (0.59%)	37.85% Avg for View: 37.76% (0.25%)	$0.00 % of Total: 0.00% ($0.00)
1.	/ukm/c/	5,164 (18.89%)	3,801 (19.28%)	00:00:55	3,709 (35.86%)	56.70%	56.66%	$0.00 (0.00%)
2.	/ukm/b/	4,737 (17.33%)	3,385 (17.17%)	00:01:02	3,281 (31.72%)	52.45%	51.61%	$0.00 (0.00%)
3.	/ukm/a/	4,222 (15.45%)	3,123 (15.84%)	00:00:52	3,039 (29.38%)	52.45%	50.76%	$0.00 (0.00%)
4.	/ukm/b/data-diri/	2,200 (8.05%)	1,497 (7.59%)	00:03:30	76 (0.73%)	51.32%	30.32%	$0.00 (0.00%)
5.	/ukm/c/pinjaman/	1,894 (6.93%)	1,494 (7.58%)	00:01:35	35 (0.34%)	71.43%	38.01%	$0.00 (0.00%)
6.	/ukm/a/survei/	2,270 (8.30%)	1,392 (7.06%)	00:00:37	44 (0.43%)	54.55%	10.66%	$0.00 (0.00%)
7.	/ukm/a/detil-survei/	1,913 (7.00%)	1,156 (5.86%)	00:00:31	24 (0.23%)	50.00%	6.33%	$0.00 (0.00%)
8.	/ukm/a/data-diri/	1,725 (6.31%)	1,127 (5.72%)	00:02:30	22 (0.21%)	59.09%	14.38%	$0.00 (0.00%)
9.	/ukm/a/pinjaman/	838 (3.07%)	751 (3.81%)	00:02:14	22 (0.21%)	68.18%	30.91%	$0.00 (0.00%)
10.	/ukm/b/pinjaman/	569 (2.08%)	501 (2.54%)	00:02:21	26 (0.25%)	42.31%	36.20%	$0.00 (0.00%)

Show rows: 10 | Go to: 1 | 1 - 10 of 21

This report was generated on 1/31/18 at 7:05:00 PM - Refresh Report

Figure 4.2: Table google analytics mekargo.id

4.5 Analyze Test Results

Data yang didapat dari google analytic dilakukan pemrosesan dan analisa dengan metode bayesian inference dengan pymc. Mengimport seluruh library python yang dibutuhkan yaitu pymc3, numpy, Ipython, matplotlib, dan scipy.

```
In [1]: import pymc3 as pm
        import numpy as np
        %matplotlib inline
        from IPython.core.pylabtools import figsize
        import matplotlib.pyplot as plt
        import scipy.stats as stats
        figsize(12.5, 4)
```

Figure 4.3: Import python library

Inisialisasi nilai pada versi A, B, dan C serta banyaknya sample yang digunakan.

```
In [2]: true_A = 120
        true_B = 129
        true_C = 84

        N_sample = 1156
```

Figure 4.4: Initialize sample

Menghitung nilai peluang A, B, dan C. Hasilnya adalah:
true_p_A = 0.10380622837370242
true_p_B = 0.1115916955017301
true_p_C = 0.0726643598615917

```
In [3]: true_p_A = true_A/float(N_sample)
        true_p_B = true_B/float(N_sample)
        true_p_C = true_C/float(N_sample)

        print("true p_A:", true_p_A)
        print("true p_B:", true_p_B)
        print("true p_C:", true_p_C)

true p_A: 0.10380622837370242
true p_B: 0.1115916955017301
true p_C: 0.0726643598615917
```

Figure 4.5: Calculate probability

Melakukan observasi bernoulli terhadap nilai peluang A, B, dan C menggunakan method stats pada library scipy

```
In [4]: observations_A = stats.bernoulli.rvs(true_p_A, size=N_sample)
        observations_B = stats.bernoulli.rvs(true_p_B, size=N_sample)
        observations_C = stats.bernoulli.rvs(true_p_C, size=N_sample)

        print("Obs from Site A: ", observations_A[:30], "...")
        print("Obs from Site B: ", observations_B[:30], "...")
        print("Obs from Site C: ", observations_C[:30], "...")

Obs from Site A:  [0 0 1 0 0 1 0 0 0 0 0 0 0 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0] ...
Obs from Site B:  [0 1 0 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 1 0 0] ...
Obs from Site C:  [0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0] ...
```

Figure 4.6: Bernoulli observation

Mencetak nilai jumlah dari nilai true yang dihasilkan oleh observasi bernoulli,

dengan hasil sebagai berikut

sum_true_p_A = 114

sum_true_p_B = 138

sum_true_p_C = 86

Mencetak hasil nilai rata-rata observasi bernoulli dengan bantuan method mean pada library numpy. Nilai yang dihasilkan adalah:

mean_p_A = 0.098615916955

mean_p_B = 0.11937716263

mean_p_C = 0.0743944636678

Nilai rata rata ini sekaligus menjadi nilai true frequency

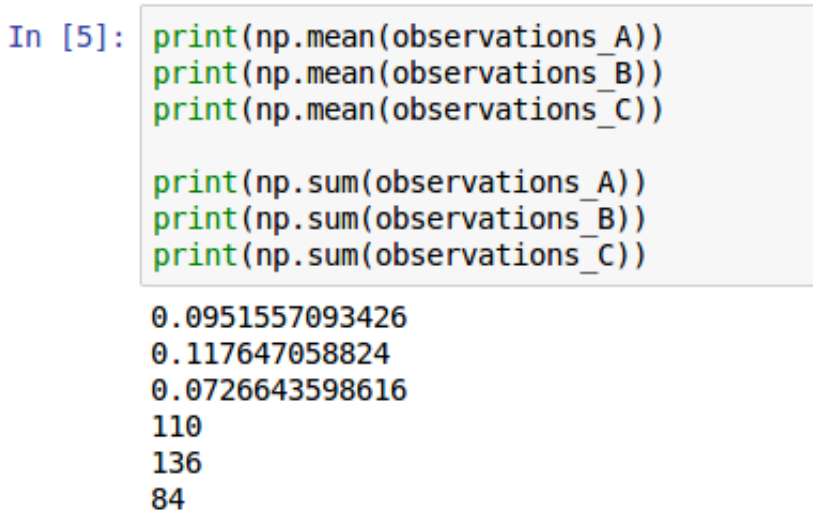


Figure 4.7: Sum and mean of bernoulli observation

Pymc probability models, jelasin dari model uniform sampling, deterministik nilai posterior a-b, a-c, bc. deterministik bernouli ke model, metropolis dan sampling total data 20000 diambil 1000 awal

```
In [6]: with pm.Model() as model:
            p_A = pm.Uniform("p_A", 0, 1)
            p_B = pm.Uniform("p_B", 0, 1)
            p_C = pm.Uniform("p_C", 0, 1)

            # Define the deterministic delta function. This is our unknown of interest.
            delta_A_B = pm.Deterministic("delta_A_B", p_A - p_B)
            delta_A_C = pm.Deterministic("delta_A_C", p_A - p_C)
            delta_B_C = pm.Deterministic("delta_B_C", p_B - p_C)

            # Set of observations, in this case we have three observation datasets.
            obs_A = pm.Bernoulli("obs_A", p_A, observed=observations_A)
            obs_B = pm.Bernoulli("obs_B", p_B, observed=observations_B)
            obs_C = pm.Bernoulli("obs_C", p_C, observed=observations_C)

            step = pm.Metropolis()
            trace = pm.sample(20000, step=step)
            burned_trace=trace[1000:]
100%|██████████| 20500/20500 [00:31<00:00, 643.38it/s]
```

Figure 4.8: Pymc probabilistic model

menyimpan hasil processing pymc probabilistik model ke variable - variable sebagai bentuk visualisasi dan hasil analisis data

```
In [7]: p_A_samples = burned_trace["p_A"]
        p_B_samples = burned_trace["p_B"]
        p_C_samples = burned_trace["p_C"]
        delta_A_B_samples = burned_trace["delta_A_B"]
        delta_A_C_samples = burned_trace["delta_A_C"]
        delta_B_C_samples = burned_trace["delta_B_C"]
```

Figure 4.9: Pymc probabilistic model results

posterior distribution probabilistik A, deskripsiin isi codingan

```
In [8]: figsize(12.5, 10)

        #histogram of posteriors

        ax = plt.subplot(311)

        plt.xlim(.06, .2)
        plt.hist(p_A_samples, histtype='stepfilled', bins=25, alpha=0.85,
                 label="posterior of $p_A$", color="#A60628", normed=True)
        plt.vlines(true_p_A, 0, 80, linestyle="--", label="true $p_A$ (unknown)")
        plt.legend(loc="upper right")
        plt.title("Posterior distributions of $p_A$, $p_B$, and delta unknowns")

Out[8]: Text(0.5,1,'Posterior distributions of $p A$, $p B$, and delta unknowns')
```

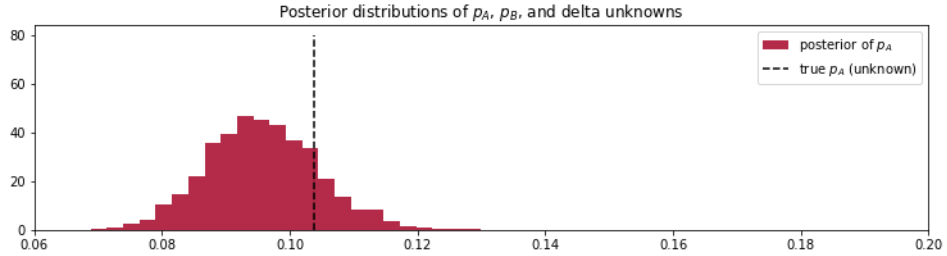


Figure 4.10: Posteriror distribution P_A

posterior distribution probabilistik B, deskripsiin isi codingan

```
In [9]: ax = plt.subplot(312)

        plt.xlim(.06, .2)
        plt.hist(p_B_samples, histtype='stepfilled', bins=25, alpha=0.85,
                 label="posterior of $p_B$", color="#467821", normed=True)
        plt.vlines(true_p_B, 0, 80, linestyle="--", label="true $p_B$ (unknown)")
        plt.legend(loc="upper right")

Out[9]: <matplotlib.legend.Legend at 0x7f03334969e8>
```

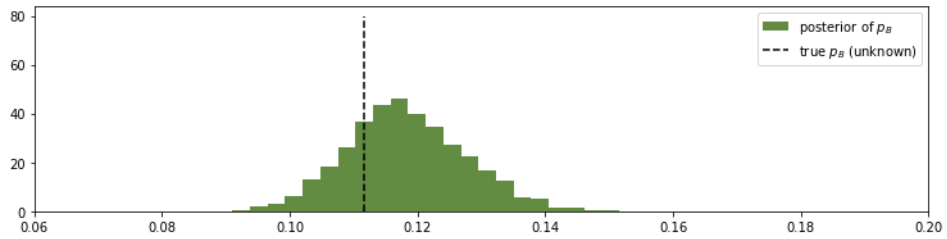


Figure 4.11: Posteriror distribution P_B

posterior distribution probabilistik C, deskripsiin isi codingan

```
In [10]: ax = plt.subplot(313)

         plt.xlim(0, .1)
         plt.hist(p_C_samples, histtype='stepfilled', bins=25, alpha=0.85,
                  label="posterior of $p_C$", color="#D6F841", normed=True)
         plt.vlines(true_p_C, 0, 80, linestyle="--", label="true $p_C$ (unknown)")
         plt.legend(loc="upper right")

Out[10]: <matplotlib.legend.Legend at 0x7f0332445a90>
```

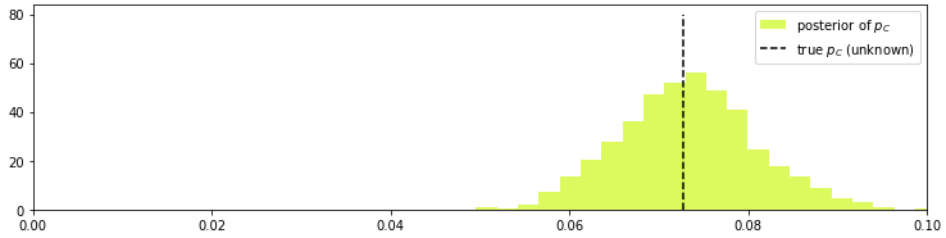


Figure 4.12: Posteriror distribution P_C

posterior distribution delta A-B, deskripsiin isi codingan

```
In [11]: ax = plt.subplot(313)
         plt.hist(delta_A_B_samples, histtype='stepfilled', bins=30, alpha=0.85,
                  label="posterior of delta A-B", color="#7A68A6", normed=True)
         plt.vlines(true_p_A - true_p_B, 0, 60, linestyle="--",
                    label="true delta (unknown)")
         plt.vlines(0, 0, 60, color="black", alpha=0.2)
         plt.legend(loc="upper right");
```

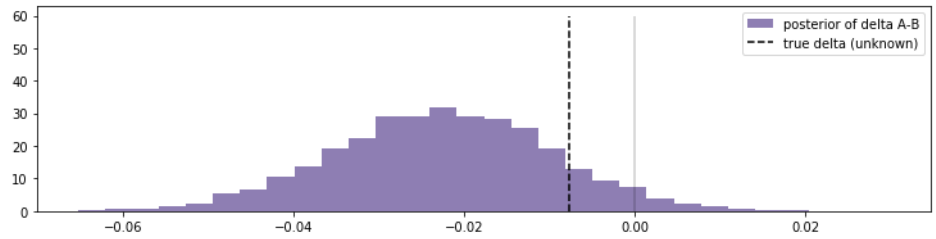


Figure 4.13: Posteriror distribution delta A-B

Hasil akhir kombinasi probabilitas seluruh versi.

In [14]:
```
# Count the number of samples less than 0, i.e. the area under the curve
# before 0, represent the probability that site A is worse than site B.
print("Probability site A is WORSE than site B: %.3f" % \
    np.mean(delta_A_B_samples < 0))

print("Probability site A is BETTER than site B: %.3f" % \
    np.mean(delta_A_B_samples > 0))

print("\nProbability site A is WORSE than site C: %.3f" % \
    np.mean(delta_A_C_samples < 0))

print("Probability site A is BETTER than site C: %.3f \n" % \
    np.mean(delta_A_C_samples > 0))

print("Probability site B is WORSE than site C: %.3f" % \
    np.mean(delta_B_C_samples < 0))

print("Probability site B is BETTER than site C: %.3f" % \
    np.mean(delta_B_C_samples > 0))
```

```
Probability site A is WORSE than site B: 0.961
Probability site A is BETTER than site B: 0.039

Probability site A is WORSE than site C: 0.025
Probability site A is BETTER than site C: 0.975

Probability site B is WORSE than site C: 0.000
Probability site B is BETTER than site C: 1.000
```

Figure 4.14: Final result combination of all variants

Chapter 5

CONCLUSION AND SUGGESTIONS

5.1 Conclusion

Metode penelitian yang dilakukan untuk melakukan A/B testing pada website mekargo.id meliputi: identifying problems, defining website measurement, developing a hypothesis, developing and testing page variants, dan analyzing test results. Cara menganalis hasil A/B testing dengan metode bayesian inference dan tools pymc3 dilakukan melalui Metropolis-Hastings algorithm sebagai teknik sampling, ipython dan jupyter notebook sebagai environment pemrograman, scipy untuk memopulasi bernoulli distribution, numpy sebagai penyimpan numerikal data berbentuk array, dan matplotlib sebagai penampil grafik hasil pengolahan data. Dari hasil akhir seluruh kombinasi probabilitas yang dihasilkan dapat disimpulkan bahwa varian B adalah hasil yang terbaik karena selalu lebih baik saat dibandingkan dengan varian A dan C.

5.2 Suggestions

Penelitian berikutnya dapat dicoba untuk melakukan A/B testing dengan varian lebih banyak dan pengembangan metode bayesian inference dengan algoritma multi-arm bandit.

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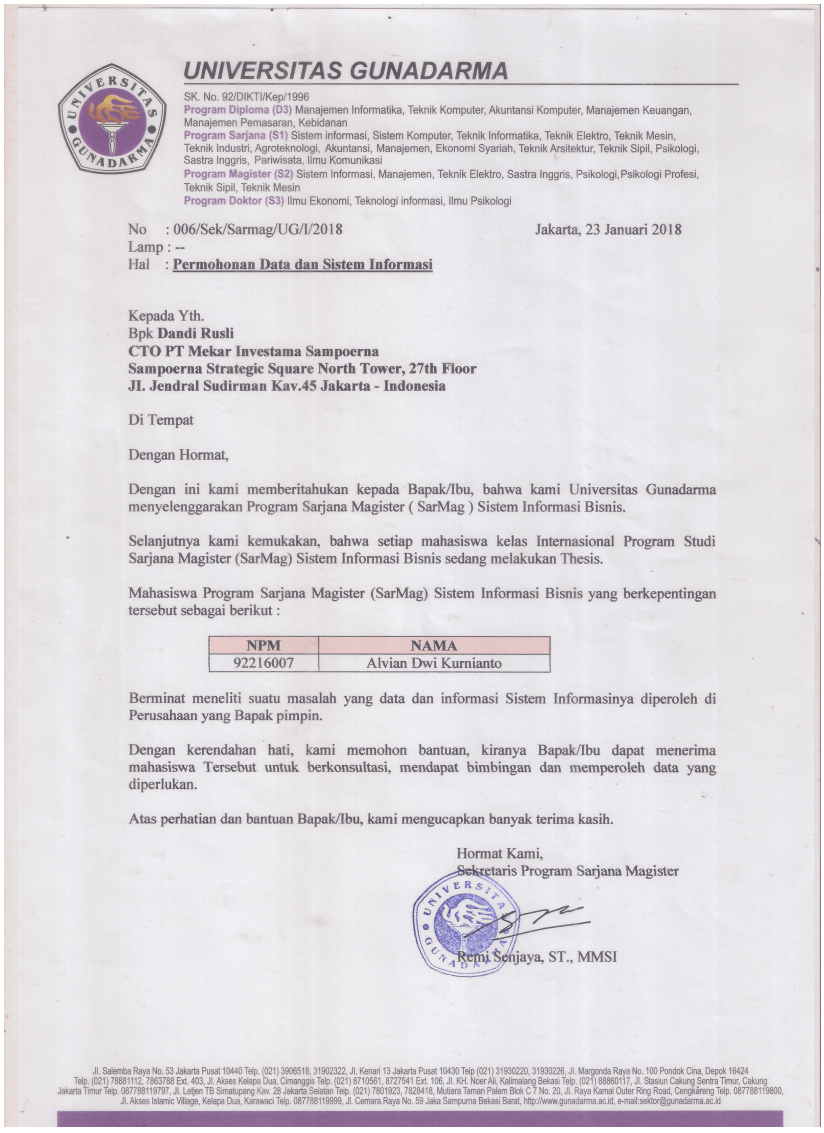
Appendix

Figure A.1: Letter of data and information permission request



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No : 006/Sek/Sarmag/UG/I/2018 Jakarta, 23 Januari 2018
Lamp : --
Hal : **Permohonan Data dan Sistem Informasi**

Kepada Yth.
Bpk **Dandi Rusli**
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Di Tempat

Dengan Hormat,

Dengan ini kami memberitahukan kepada Bapak/Ibu, bahwa kami Universitas Gunadarma menyelenggarakan Program Sarjana Magister (SarMag) Sistem Informasi Bisnis.

Selanjutnya kami kemukakan, bahwa setiap mahasiswa kelas Internasional Program Studi Sarjana Magister (SarMag) Sistem Informasi Bisnis sedang melakukan Thesis.

Mahasiswa Program Sarjana Magister (SarMag) Sistem Informasi Bisnis yang berkepentingan tersebut sebagai berikut :

NPM	NAMA
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Berminat meneliti suatu masalah yang data dan informasi Sistem Informasinya diperoleh di Perusahaan yang Bapak pimpin.

Dengan kerendahan hati, kami memohon bantuan, kiranya Bapak/Ibu dapat menerima mahasiswa Tersebut untuk berkonsultasi, mendapat bimbingan dan memperoleh data yang diperlukan.

Atas perhatian dan bantuan Bapak/Ibu, kami mengucapkan banyak terima kasih.

Hormat Kami,
Sekretaris Program Sarjana Magister

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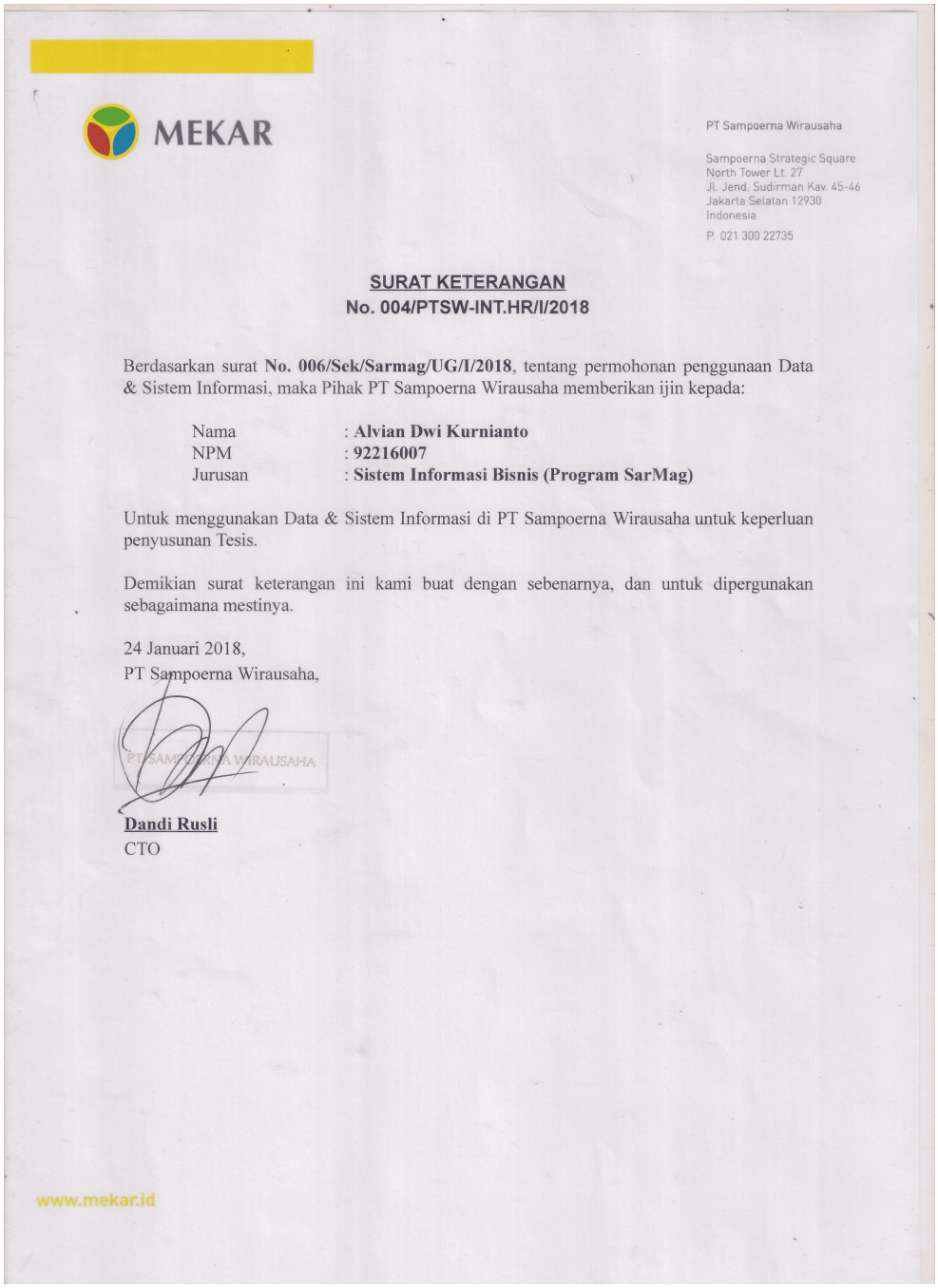
Figure A.2: Letter of data and information usage permission



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Berdasarkan surat **No. 006/Sek/Sarmag/UG/I/2018**, tentang permohonan penggunaan Data & Sistem Informasi, maka Pihak PT Sampoerna Wirausaha memberikan ijin kepada:

Nama	: **Alvian Dwi Kurnianto**
NPM	: **92216007**
Jurusan	: **Sistem Informasi Bisnis (Program SarMag)**

Untuk menggunakan Data & Sistem Informasi di PT Sampoerna Wirausaha untuk keperluan penyusunan Tesis.

Demikian surat keterangan ini kami buat dengan sebenarnya, dan untuk dipergunakan sebagaimana mestinya.

24 Januari 2018,
PT Sampoerna Wirausaha,

PT SAMPOERNA WIRAUSAHA

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